IN THE CLAIMS

1. (original) A cooling system for a heat emitting device, the cooling system operating using a fluid having a liquid phase, the cooling system comprising:

a substrate including at least a portion of microchannel disposed therein, the substrate adapted to physically connect to the heat emitting device, thereby providing for the transfer of thermal energy from the heat emitting device to the substrate, and the further transfer of thermal energy from the substrate to the fluid disposed within the microchannel, the microchannel configured to provide flow of the fluid therethrough;

a heat exchanger configured to provide flow of the fluid therethrough and the transfer of thermal energy out of the fluid;

an electroosmotic pump, the electroosmotic pump creating the flow of the fluid; and

wherein the substrate, the heat exchanger, and the electroosmotic pump are configured to operate together to create a closed loop fluid flow.

2.-114. (cancelled)

115. (new) A heat exchanger connected to a heat-generating device in a cooling system wherein the heat exchanger operates using a fluid having a liquid phase, comprising:

a substrate fabricated from a material selected for its thermal conduction capability and adapted to connect to the heat-generating device; and

a microchannel disposed in the substrate for transfer of thermal energy to the fluid as the fluid is pumped through the heat exchanger wherein the arrangement of the microchannel is selected to minimize the temperature differences across the heat-generating device.

116. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate material is selected based on an approximate matching of a thermal expansion coefficient of the heat-generating device to which the heat exchanger is connected.

117. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate material is selected from a plurality of thin metal sheets, or a silicon layer and a glass layer, or a ceramic, or a carbon-fiber composite.

118. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate comprises a plurality of layers.

119. (new) The heat exchanger connected to a heat-generating device of claim 118 wherein the plurality of layers comprise different materials.

120. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate is connected to a surface of the heat-generating device by a thermal attach material.

121. (new) The heat exchanger connected to a heat-generating device of claim 120 wherein the thermal attach material is a silver-filled epoxy or solder.

122. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate and the heat-generating device are fabricated from silicon.

123. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the heat-generating device is fabricated from silicon and the substrate is fabricated from a metal.

124. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate further comprises a thermometer integrated into the heat exchanger for providing a feedback signal to a controller in response to a local change in temperature to enable dynamic temperature control within the substrate.

125. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate comprises at least two layers and the microchannel is confined to a single layer.

126. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the substrate comprises at least two layers and the microchannel is formed in more than one layer.

127. (new) The heat exchanger connected to a heat-generating device of claim 125 wherein the at least two layers are fabricated from silicon and glass and are bonded by any one of the following bonding processes: anodic, fusion, eutectic and adhesive.

128. (new) The heat exchanger connected to a heat-generating device of claim 125 wherein the at least two layers are fabricated from metal and are bonded by any one of the following: welding, soldering, eutectic bonding and adhesive bonding.

129. (new) The heat exchanger connected to a heat-generating device of claim 115 further comprising an electroosmotic pump integrated into the substrate for pumping fluid through the heat exchanger.

130. (new) The heat exchanger connected to a heat-generating device of claim 129 further comprising a microcontroller integrated into the substrate for monitoring a plurality of temperature, pressure and flow rate sensors disposed in the heat exchanger and providing a driving voltage to a power supply associated with the electroosmotic pump.

131. (new) The heat exchanger connected to a heat-generating device of claim 118 wherein the microchannel is disposed in the layer of the substrate that is in direct contact with the heat-generating device.

132. (new) The heat exchanger connected to a heat-generating device of claim 118 wherein the plurality of layers comprise a bottom layer, at least one middle layer and a top layer, and each of the bottom, middle and top layers may be fabricated from a different material.

133. (new) The heat exchanger connected to a heat-generating device of claim 132 wherein the bottom layer is fabricated from a metal, or silicon, or glass, or a ceramic, or a plastic.

134. (new) The heat exchanger connected to a heat-generating device of claim 133 wherein the bottom layer is fabricated from copper.

135. (new) The heat exchanger connected to a heat-generating device of claim 133 wherein the bottom layer is fabricated from Kovar.

136. (new) The heat exchanger connected to a heat-generating device of claim 132 wherein the at least one middle layer is fabricated from silicon.

137. (new) The heat exchanger connected to a heat-generating device of claim 132 wherein the at least one middle layer is fabricated from a metal.

138. (new) The heat exchanger connected to a heat-generating device of claim 132 wherein the top layer is fabricated from a glass or a plastic.

139. (new) The heat exchanger connected to a heat-generating device of claim 115 wherein the heat-generating device includes a plurality of regions with several regions having a higher heat density than other regions.

140. (new) A heat exchanger connected to a heat-generating device in a cooling system wherein the heat exchanger operates using a fluid having a liquid phase, comprising:

a substrate fabricated from a material selected for its thermal conduction capability and adapted to connect to the heat-generating device; and

a microchannel disposed in the substrate for transfer of thermal energy to the fluid as the fluid is pumped through the heat exchanger wherein at least one inlet and at least one outlet are positioned on a side of the heat exchanger.

141. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the substrate material is selected based on an approximate matching of a thermal expansion coefficient of the heat-generating device to which the heat exchanger is connected.

142. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the substrate material is selected from a plurality of thin metal sheets, or a silicon layer and a glass layer, or a ceramic, or a carbon-fiber composite.

143. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the substrate comprises a plurality of layers.

144. (new) The heat exchanger connected to a heat-generating device of claim 143 wherein the plurality of layers comprise different materials.

145. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the substrate is connected to a surface of the heat-generating device by a thermal attach material.

146. (new) The heat exchanger connected to a heat-generating device of claim 145 wherein the thermal attach material is a silver-filled epoxy or solder.

147. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the substrate and the heat-generating device are fabricated from silicon.

148. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the heat-generating device is fabricated from silicon and the substrate is fabricated from a metal.

149. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the substrate further comprises a thermometer integrated into the heat exchanger for providing a feedback signal to a controller in response to a local change in temperature to enable dynamic temperature control within the substrate.

150. (new) The heat exchanger connected to a heat-generating device of claim 140 wherein the substrate comprises at least two layers and the microchannel is confined to a single layer.

151. (new) The heat exchanger connected to a heat-generating device of claim 150 wherein the substrate comprises at least two layers and the microchannel is formed in more than one layer.

152. (new) The heat exchanger connected to a heat-generating device of claim 150 wherein the at least two layers are fabricated from silicon and glass and are bonded by any one of the following bonding processes: anodic, fusion, eutectic and adhesive.

153. (new) The heat exchanger connected to a heat-generating device of claim 150 wherein the at least two layers are fabricated from metal and are bonded by any one of the following: welding, soldering, eutectic bonding and adhesive bonding.

154. (new) The heat exchanger connected to a heat-generating device of claim 150 further comprising an electroosmotic pump integrated into the substrate for pumping fluid through the heat exchanger.

155. (new) The heat exchanger connected to a heat-generating device of claim 154 further comprising a microcontroller integrated into the substrate for monitoring a plurality of

temperature, pressure and flow rate sensors disposed in the heat exchanger and providing a driving voltage to a power supply associated with the electroosmotic pump.

156. (new) The heat exchanger connected to a heat-generating device of claim 143 wherein the microchannel is disposed in the layer of the substrate that is in direct contact with the heat-generating device.

157. (new) The heat exchanger connected to a heat-generating device of claim 143 wherein the plurality of layers comprise a bottom layer, at least one middle layer and a top layer, and each of the bottom, middle and top layers may be fabricated from a different material.

158. (new) The heat exchanger connected to a heat-generating device of claim 157 wherein the bottom layer is fabricated from a metal, or silicon, or glass, or a ceramic, or a plastic.

159. (new) The heat exchanger connected to a heat-generating device of claim 158 wherein the bottom layer is fabricated from copper.

160. (new) The heat exchanger connected to a heat-generating device of claim 158 wherein the bottom layer is fabricated from Kovar.

161. (new) The heat exchanger connected to a heat-generating device of claim 157 wherein the at least one middle layer is fabricated from silicon.

162. (new) The heat exchanger connected to a heat-generating device of claim 157 wherein the at least one middle layer is fabricated from a metal.

163. (new) The heat exchanger connected to a heat-generating device of claim 157 wherein the top layer is fabricated from a glass or a plastic.

164. (new) A heat exchanger for the transfer of heat from a heat-generating device in a cooling system wherein the heat exchanger operates using a fluid having a liquid phase, comprising:

a multi-layer substrate fabricated from a plurality of materials that are bonded together and attached to the heat-generating device; and

a microchannel disposed in at least one layer of the substrate for transfer of thermal energy to the fluid as the fluid is pumped through the heat exchanger wherein the arrangement of the microchannel is selected to minimize the temperature differences across the heat-generating device.

165. (new) The heat exchanger for the transfer of heat of claim 164 wherein the heat-generating device includes a plurality of regions with several regions having a higher heat density than other regions.

166. (new) A heat exchanger for the transfer of heat from a heat-generating device in a cooling system wherein the heat exchanger operates using a fluid having a liquid phase, comprising:

a multi-layer substrate fabricated from a plurality of materials that are bonded together and attached to the heat-generating device; and

a microchannel disposed in at least one layer of the substrate for transfer of thermal energy to the fluid as the fluid is pumped through the heat exchanger wherein at least one inlet and at least one outlet are positioned on a side of the heat exchanger.

167. (new) A cooling system for a heat emitting device, the cooling system operating using a fluid having a liquid phase, the cooling system comprising:

a substrate including at least a portion of a microchannel disposed therein, the substrate adapted to physically connect to the heat emitting device, thereby providing for the transfer of thermal energy from the heat emitting device to the substrate, and the further transfer of thermal energy from the substrate to the fluid disposed within the microchannel, the microchannel configured to provide flow of the fluid therethrough and wherein the arrangement of the microchannel is selected to minimize the temperature differences across the heat emitting device;

a heat exchanger configured to provide flow of the fluid therethrough and the transfer of thermal energy out of the fluid;

a fluid pump for creating the flow of the fluid; and

wherein the substrate, the heat exchanger, and the fluid pump are configured to operate together to create a closed loop fluid flow.

168. (new) The cooling system according to claim 167 wherein the fluid pump is disposed between the heat exchanger and the substrate such that the fluid is pumped into the microchannel of the substrate from the fluid pump.

169. (new) The cooling system according to claim 167 wherein the microchannel includes a plurality of parallel subchannels, each of the parallel subchannels sharing a common inlet portion and a common outlet portion.

170. (new) The cooling system according to claim 169 further including a temperature sensor disposed in proximity to the plurality of parallel subchannels.

171. (new) The cooling system according to claim 170 further including a temperature control circuit that receives as inputs signals from the temperature sensor.

172. (new) The cooling system according to claim 167 wherein the substrate is comprised of a plurality of layers, and wherein at least a portion of the microchannel is formed within both a first and a second layer.

173. (new) The cooling system according to claim 167 wherein the substrate is comprised of a first layer and a second layer, the first layer being physically connected to the heat emitting device, and wherein at least a portion of the microchannel is formed within only the first layer.

174. (new) The cooling system according to claim 167 wherein the heat emitting device is comprised of a plurality of integrated circuits and the substrate is disposed between the plurality of integrated circuits.

175. (new) The cooling system according to claim 167 wherein the heat emitting device includes a plurality of regions with several regions having a higher heat density than other regions.

176. (new) The cooling system according to claim 167 wherein the substrate further includes a plurality of vertical electrical interconnects.

177. (new) The cooling system according to claim 176 wherein the microchannel further includes vertical and horizontal fluid channels.

178. (new) The cooling system according to claim 176 wherein the plurality of vertical interconnects provide a portion of an electrical connection that electrically connects a plurality of temperature sensors to a temperature control circuit.

179. (new) The cooling system according to claim 167 wherein the substrate includes an opening through which another interaction is capable of impinging upon a portion of the heat emitting device.

180. (new) The cooling system according to claim 179 wherein the another interaction is an electrical interaction.

181. (new) The cooling system according to claim 179 wherein the another interaction is an electrical connection to a surface of the device to which the substrate is physically connected, and which electrical connection does not pass through any portion of the substrate.

182. (new) The cooling system according to claim 179 wherein the another interaction is one of pressure, sound, chemical, mechanical force, and an electromagnetic field.

183. (new) The cooling system according to claim 179 wherein the opening is created by a surface area of the substrate that contacts a corresponding surface area of the device being smaller than the corresponding surface area of the device.

184. (new) The cooling system according to claim 167 wherein a portion of the microchannel includes:

an upper chamber;

a lower chamber; and

a plurality of subchannels disposed between the upper chamber and the lower chamber wherein the arrangement of the subchannels is selected to minimize the temperature differences across the heat emitting device.

185. (new) The cooling system according to claim 167 further including a pressure sensor.

186. (new) The cooling system according to claim 167 further including a temperature sensor disposed within the substrate.

187. (new) The cooling system according to claim 186 further including a temperature control circuit that receives as inputs signals from the temperature sensor.

188. (new) The cooling system according to claim 167 further including a temperature sensor disposed in the loop at a location other than within the substrate.

189. (new) The cooling system according to claim 167 wherein the microchannel includes a portion containing a partial blocking structure to increase surface area contacting the fluid.

190. (new) The cooling system according to claim 189 wherein the partial blocking structure is comprised of a roughened portion of a microchannel wall.

191. (new) The cooling system according to claim 189 wherein the partial blocking structure is disposed within the microchannel.

192. (new) The cooling system according to claim 167 wherein the heat emitting device includes a plurality of regions with several regions having a higher heat density than other regions.

193. (new) A cooling system for a heat emitting device, the cooling system operating using a fluid having a liquid phase, the cooling system comprising:

a substrate including at least a portion of a microchannel disposed therein, the substrate adapted to physically connect to the heat emitting device, thereby providing for the transfer of thermal energy from the heat emitting device to the substrate, and the further transfer of thermal energy from the substrate to the fluid disposed within the microchannel, the microchannel configured to provide flow of the fluid therethrough;

a heat exchanger configured to provide for (i) the flow of the fluid therethrough, wherein at least one inlet and at least one outlet are positioned on a side of the heat exchanger, and (ii) the transfer of thermal energy out of the fluid;

a fluid pump for creating the flow of the fluid; and

wherein the substrate, the heat exchanger, and the fluid pump are configured to operate together to create a closed loop fluid flow.

194. (new) The cooling system according to claim 193 wherein the fluid pump is disposed between the heat exchanger and the substrate such that the fluid is pumped into the microchannel of the substrate from the fluid pump.

195. (new) The cooling system according to claim 193 wherein the microchannel includes a plurality of parallel subchannels, each of the parallel subchannels sharing a common inlet portion and a common outlet portion.

196. (new) The cooling system according to claim 195 further including a temperature sensor disposed in proximity to the plurality of parallel subchannels.

197. (new) The cooling system according to claim 196 further including a temperature control circuit that receives as inputs signals from the temperature sensor.

198. (new) The cooling system according to claim 193 wherein the substrate is comprised of a plurality of layers, and wherein at least a portion of the microchannel is formed within both a first and a second layer.

199. (new) The cooling system according to claim 193 wherein the substrate is comprised of a first layer and a second layer, the first layer being physically connected to the heat emitting device, and wherein at least a portion of the microchannel is formed within only the first layer.

200. (new) The cooling system according to claim 193 wherein the heat emitting device is comprised of a plurality of integrated circuits and the substrate is disposed between the plurality of integrated circuits.

201. (new) The cooling system according to claim 193 wherein the substrate further includes a plurality of vertical electrical interconnects.

202. (new) The cooling system according to claim 201 wherein the microchannel further includes vertical and horizontal fluid channels.

203. (new) The cooling system according to claim 201 wherein the plurality of vertical interconnects provide a portion of an electrical connection that electrically connects a plurality of temperature sensors to a temperature control circuit.

204. (new) The cooling system according to claim 193 wherein the substrate includes an opening through which another interaction is capable of impinging upon a portion of the heat emitting device.

205. (new) The cooling system of claim 204 wherein the another interaction is an electrical interaction.

206. (new) The cooling system according to claim 204 wherein the another interaction is an electrical connection to a surface of the device to which the substrate is physically connected, and which electrical connection does not pass through any portion of the substrate.

207. (new) The cooling system according to claim 204 wherein the another interaction is one of pressure, sound, chemical, mechanical force, and an electromagnetic field.

208. (new) The cooling system according to claim 204 wherein the opening is created by a surface area of the substrate that contacts a corresponding surface area of the device being smaller than the corresponding surface area of the device.

209. (new) A thermal transfer apparatus connected to a semiconductor heat emitting device, the thermal transfer apparatus operating using a fluid having a liquid phase comprising:

a substrate adapted to physically connect to the semiconductor heat emitting device;

a plurality of fluid inlets disposed in the substrate;

a plurality of fluid outlets disposed in the substrate; and

a plurality of microchannels connected between the plurality of fluid inlets and the plurality of fluid outlets, the plurality of microchannels thereby providing a plurality of independent fluid flow paths.

210. (new) The apparatus according to claim 209 wherein the arrangement of the microchannels is selected to minimize the temperature difference across the heat emitting device.

211. (new) The apparatus according to claim 210 further including a plurality of temperature sensors respectively located in proximity to the plurality of microchannels, such that each

of the temperature sensors detects thermal energy generated by the heat emitting device in proximity to said each temperature sensor.

212. (new) The apparatus according to claim 211 further including a control circuit electrically connected to the plurality of temperature sensors, the control circuit inputting signals from the plurality of temperature sensors and providing a control signal for controlling the fluid pump.

213. (new) The apparatus according to claim 212 further including a second fluid pump, such that the first fluid pump pumps the fluid through one microchannel and the second fluid pump pumps the fluid through another microchannel and wherein the control circuit controls the first and second fluid pumps, the control circuit being capable of independently controlling the pumping of fluid through each of the first and second fluid pumps.

214. (new) The apparatus according to claim 210 further including:

a plurality of temperature sensors disposed within the substrate, such that a first temperature sensor detects thermal energy generated by the heat emitting device in proximity to the first temperature sensor and a second temperature sensor detects thermal energy generated by the heat emitting device in proximity to the second temperature sensor; and

a control circuit electrically connected to the first and second temperature sensors, the control circuit inputting signals from a first and second temperature sensors and providing a control signal for controlling the fluid pump.

215. (new) The apparatus according to claim 214 wherein the control circuit operates to sense a predetermined condition.

216. (new) The apparatus according to claim 215 wherein upon sensing the condition, the control circuit causes a reversal of the fluid flow for a period of time.

217. (new) The apparatus according to claim 215 wherein the control circuit detects a change in temperature over a period of time and correspondingly adjusts the fluid flow within the fluid pump to compensate for the change in temperature.

218. (new) The apparatus according to claim 209 further including a plurality of temperature sensors respectively located in proximity to the plurality of microchannels, such that each temperature sensor detects thermal energy generated by the heat emitting device in proximity to said each temperature sensor.

219. (new) The apparatus according to claim 209 wherein each of the plurality of microchannels contain portions that are disposed parallel and adjacent to one another such that fluid flow in one microchannel occurs in a direction opposite the fluid flow in another microchannel.

220. (new) The apparatus according to claim 209 wherein a first microchannel is at least partially disposed over a high thermal energy location of the heat emitting device and a second microchannel is disposed over another portion of the heat emitting device different from the high thermal energy location.

221. (new) The cooling system according to claim 209 wherein the substrate further includes a plurality of vertical electrical interconnects.

222. (new) The cooling system according to claim 221 wherein the plurality of vertical interconnects provide a portion of an electrical connection that electrically connects a plurality of temperature sensors to a temperature control circuit.

223. (new) The cooling system according to claim 209 wherein the substrate includes an opening through which another interaction is capable of impinging upon a portion of the heat emitting device.

224. (new) The cooling system according to claim 223 wherein the another interaction is an electrical interaction.

225. (new) The cooling system according to claim 224 wherein the electrical interaction is an electrical connection to a surface of the device to which the substrate is physically

connected, and which electrical connection does not pass through any portion of the substrate.

226. (new) The cooling system according to claim 223 wherein the another interaction is one of pressure, sound, chemical, mechanical force, and an electromagnetic field.

227. (new) The cooling system according to claim 223 wherein the opening is a vertical column having enclosed sidewalls.

228. (new) The cooling system according to claim 209 wherein a portion of at least one of the plurality of microchannels includes:

an upper chamber;

a lower chamber; and

a plurality of subchannels disposed between the upper chamber and the lower chamber.

229. (new) The cooling system according to claim 228 wherein the arrangement of the microchannels is selected to minimize the temperature difference across the heat emitting device.